THE IOWA-NEBRASKA TORNADOES OF EASTER SUNDAY, 1913

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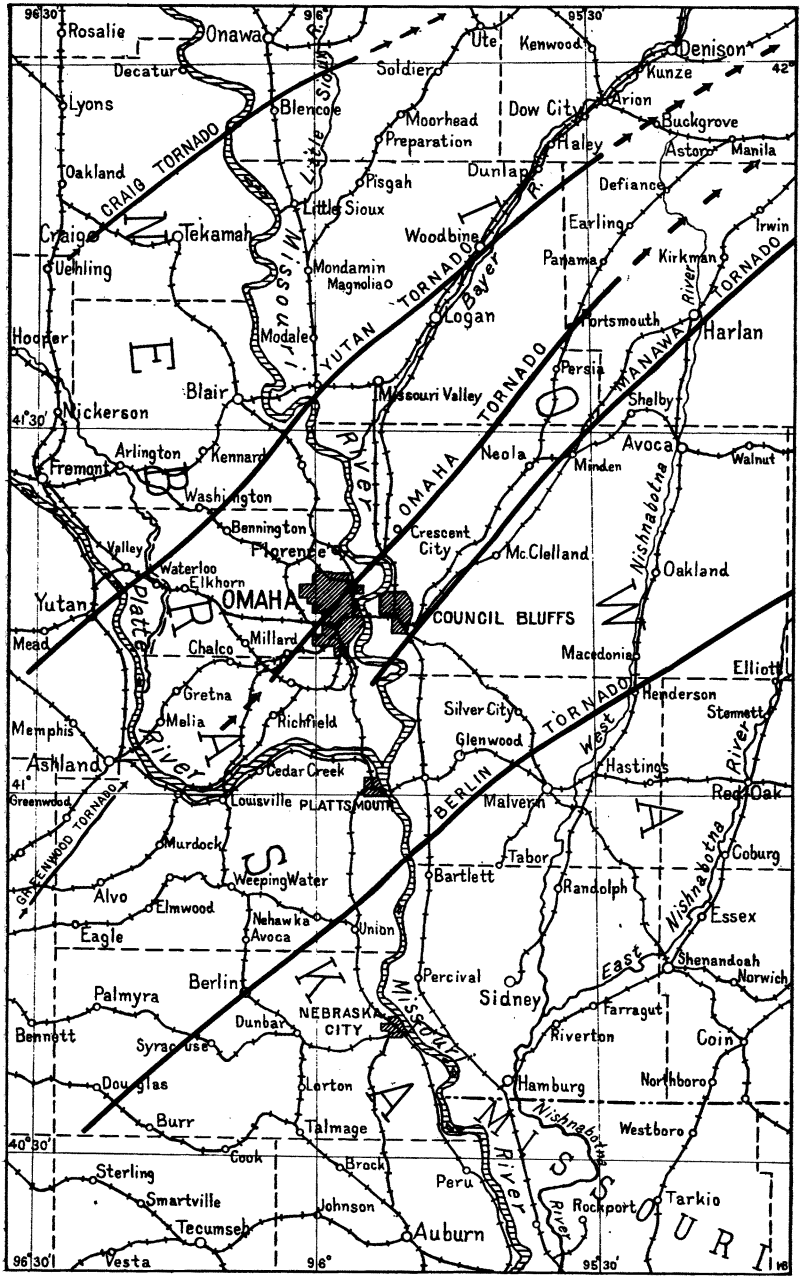
Unusual atmospheric conditions passed over Nebraska and Iowa on March 23, 1913, developing five tornadoes, which did more damage in Nebraska than all those previously recorded. Immediately after these storms a thorough survey of the districts affected in Nebraska was made under the direction of the Nebraska Conservation and Public Welfare Commission. The writers of this paper traveled over the tornado paths, mapped them, and observed the effects of the storm upon forests, farmstead improvements, towns, farm animals, and people. This paper briefly reviews the results of the field survey giving the distribution, phenomena and effects of the storms.

Weather Conditions. The tornadoes occurred as local developments in a cyclone of much energy and about average size which moved across the country from the Pacific coast to northeastern Michigan from March 21st to 24th. The morning weather map of March 23, 1913, shows the cyclone as a well defined area of low pressure covering the southern Rocky Mountain region, the center in northeastern Colorado with a pressure slightly less than 29.40 inches. This area moved eastward and slightly northward during the day, across Kansas and Nebraska, and twelve hours later, at the evening observation, 7 p. m., the center was in western Iowa, with a pressure between 29.25 and 29.30 inches. In the late afternoon, between 4 and 5 o'clock the center of the area crossed eastern Nebraska, not far north of Lincoln and Omaha. Between 5 and 6 p. m. a layer of very unstable air covered a large area, ten or twelve counties, in southeastern Nebraska. At that time the unusual appearance of the clouds indicated a violent disturbance in the upper atmosphere, that is, at the cloud level and above. The clouds were low and moving rapidly, of a weird greenish yellow color, tinged purplish in places and rolling or tumbling somewhat like boiling water. They were for the most part cumulus or stratocumulus in formation, developing later into cumulo-nimbus. In a considerable part of this area a reddish dust settled from the upper atmosphere preceding the tornadoes. The dust was probably taken up from the ground by air currents.



Distribution of the Iowa-Nebraska Tornadoes of March 23, 1913.
By G. E. Condra and G. A. Loveland. Scale, 1:1,150,000.

The temperature was high during the afternoon of March 23d, but far below the record for that time of the year. The relative humidity, not unusually high, was between 75 and 85 in the morning and late afternoon, but fell rapidly with the rising temperature as shown by the trace sheet of the hygrograph at Lincoln. It was 53 at 3:50 p. m. and 78 only forty minutes later. The pressure and relative humidity both fluctuated very much between 4 and 10 p. m.

The barometer fell in southeastern Nebraska all day of March 22d and on the 23d until the time of the tornadoes. The fall was steady and not unusual, except that it was rapid on the 23d and to a very low reading. The fall at Lincoln on the 23d was .44 inch from 7 a. m. to the lowest reading at about 5:45 p. m., which was 27.94 inches actual pressure or 29.19 reduced to sea level. At Omaha the fall was .58 inch for the same time, the lowest reading being 27.93 inches or 29.09 reduced to sea level. This barometer was three-fourths of a mile from the track of the tornado and so recorded the pressure in the cyclone area rather than in the tornado path.

On the morning of the 23d in southeastern Nebraska the wind was from the south, with a velocity of eight to ten miles an hour, but it increased rapidly to between twenty and forty miles an hour by 9 a. m., remaining so until the time of the tornadoes. It then turned to northwest but continued high. There was no decided decrease in the regular southerly wind just preceding the tornadoes.

In forming the tornadoes the air of the lower layer probably moved upward, rapidly forcing its way through the mass of cold air that was moving northeastward in the upper atmosphere, thus causing considerable disturbance, as indicated by the movement of the clouds. If so, the storms were phenomena caused more by the turbulent air at and above the cloud level than by conditions in the lower levels, the tornadoes being lower manifestations of the violence in the upper air. They moved in a northeasterly direction, in parallel lines, because the upper atmosphere was moving rapidly in that direction. A light fall of rain or sleet immediately preceded the tornadoes at most places. A slight rain was general in southeastern Nebraska during the passage of the cyclonic area. The rainfall accompanying the tornado at the majority of places where it was measured was less than .5 inch, only exceeding .75 inch at a few places.

Five Distinct Tornadoes. We named the tornadoes from the

points of their greatest destruction. It is a remarkable fact that five distinct tornadoes (see map) moved northeastward in nearly parallel paths at about the same time in this cyclonic area with only ten to twenty-five miles between them, all crossing the Missouri River within a distance of eighty miles. It was difficult to obtain the correct time each passed a given point, and thus ascertain its rate of movement. From the data at hand, however, we conclude that the Craig tornado was slowest and that the others moved across the country at a rate of fifty to sixty miles an hour.

The counter-clockwise circulation of the air in the tornadoes was observed by many persons and was plainly shown by the distribution of debris in the storm paths. The tornado clouds were nearly cylindrical, of large diameter, and appeared short because the cloud level was low. They were nearly straight or slightly curved, moving with the lower extremity apparently dragging.

Craig Tornado. This formed about 5:25 p. m. a few miles southwest of Craig, Nebraska. It passed over part of Craig, and through rural communities to Iowa in a course of thirty miles. It was not violent in comparison with the other tornadoes, but demolished several buildings and killed eight people in Nebraska.

Yutan Tornado. This started at the ground level two miles east of Ithaca, Nebraska, at 5:30 p. m. We traced its continuous path of destruction over seventy miles. The width was one-fourth to one-half mile and evidenced extreme energy. Fortunately this storm narrowly missed several villages. It destroyed ninety-three sets of farm buildings and killed nineteen people in Nebraska. The greatest damage was in Yutan where fifteen persons lost their lives. Here about half of the town was demolished, yet so few were killed. A trunk was carried from Yutan to Iowa; likewise a vest and watch. A young woman, carried a quarter of a mile in the debris of a house, was uninjured. Just what destruction was wrought in Iowa is not known.

Omaha Tornado. Starting near Kramer, nearly sixty-five miles southwest of Omaha, this member of the series did not make a continuous path. It swept the ground for eight miles in the vicinity of Kramer, then rose in its course just south of Lincoln, but did some damage at College View and University Place. It formed a path beginning east of Prairie Home and extending to the Platte River. Near Kramer and southeast of Greenwood rural improvements were demolished, yet no people were killed. At the Platte the tornado lifted for a few miles. It reached the ground three

miles west of Papillion and moved across Ralston, Omaha and into Iowa. The Kramer, Greenwood, and Omaha tracks were made by one continuous storm, starting a few minutes before 5 p. m. and crossing the Missouri at 6 p. m. Persons in the country saw the clouds pass between the three well defined paths. Then too, the tornadoes had the direction and sequence in time that would suggest their relation.

This tornado destroyed about 27 groups of farm buildings in Nebraska and, in Ralston and Omaha, caused damage amounting to hundreds of thousands of dollars with a death list of one hundred people. It was not so violent as the Berlin or Yutan tornadoes and certainly did not show the energy and force exhibited in some other historic tornadoes. The three paths in Nebraska had a length of thirty-one miles, whereas the storm moved much farther than that in this state and Iowa. In Omaha a great many observations were made noting tornado phenomena. Numerous objects were collected for engineering tests at the University of Nebraska. These included pieces of trees, lumber, etc., that had been penetrated by other objects.

Immediately following the tornado, the city of Omaha and the districts affected by the other tornadoes were canvassed by insurance men and the tornado insurance written in a few weeks amounted to several millions of dollars. As a further means of protection many people also built storm cellars or caves.

Manawa Tornado. At 6:15 p. m., ten miles south of the Omaha tornado, the Manawa tornado was formed just north of Bellevue and moved northeastward nearly parallel with the other storms. It did practically no damage west of the Missouri River but was violent in Iowa.

Berlin Tornado. This, the most southerly of the series, developed at 5:55 p. m., about forty miles south and thirty miles west of the point where the Manawa tornado started. It was twenty minutes before the latter storm began, but at a point about forty-one miles from the Missouri River. The record shows that it did not reach Iowa until twenty-one minutes after the Manawa storm. The continuous path of destruction in Iowa-Nebraska was fully eighty miles long. Fifty-two groups of farm buildings were demolished in Nebraska and thirteen people were killed. Five persons were killed in Iowa.

The path of the Berlin Tornado was studied with great care. For the first eight miles it was weak. Here limbs were broken

from trees and buildings moved from foundations and damaged in a way that indicated a tornado. Farther on the path was practically continuous. Whatever was in the center was destroyed and near the edges was more or less damaged. The ground showed the effects of the severe wind. It had the appearance of being scoured much as if a swift stream of water had passed over it. The grass, cornstalks, and stubble, were left as if swept in a mighty tide in the direction in which the wind blew. The wire of fences was loaded with debris like that which floats in a water course at flood time, and in the center of the path fences were carried away, posts and all. The path averaged between one-fourth and one-half mile in width.

In the right zone of the storm path, objects were carried forward and inward, and in the left zone they were carried backward and inward. Some objects made complete circles in the storm. On the right, houses were lifted, moved northeastward, the northeast corners or sides striking the ground, as shown by marks in the soil. Then the houses were turned over, the wind entering through the bottom or places broken by the strain, and were crashed or blown to pieces and strewn over fields to the northeastward. Houses and barns on the left of the center moved into the storm from the opposite direction. This fact, that on the left of the center, some of the houses were pulled backward and inward, while on the right they were thrown forward and inward, caused many people to think that two storms had met, traveling in opposite directions. The fact that some buildings were thrown to the north and some to the south seemed to support this conclusion, but it is readily explained by the circular twisting motion of the tornado. It was observed that most of the destruction occurred on the east side of the center of the storm and that most of the debris was carried to the north and toward the center.

Evidence was sought of the explosive action so frequently given as a cause of house destruction by tornadoes. In a few cases the sides or parts of buildings seem to have fallen outward on account of a sudden decrease in pressure on the outside, but this evidence was not common. The debris of the houses was moved after the crashing and expansion had wrecked them, but inspection shows that crushing was the more important factor. Houses on the outer borders of the storm paths were damaged but usually not destroyed. They were partly turned or pulled from their foundations in the direction of the whirl with damage to the less resistant parts, such as porches, roofs, windows and chimneys.

There was strong suction, with upward currents in the storm. Doors were pulled outward from the grasp of persons in cellars and caves. Large animals including farm animals and people were lifted and carried considerable distances. The damage done by this tornado included the total destruction of 52 groups of farm equipment. Large buildings were completely torn to pieces, barns demolished, huge beams shattered, and stone fences scattered. On one farm 2,500 bushels of shelled corn absolutely disappeared and a crib with 4,000 bushels of unshelled corn was picked up and moved bodily. On the Sheldon farm, southeast of Nehawka, the damage to property amounted to $25,000. The house was torn down, three big barns and sheds, outbuildings, and fences were swept away; twenty-nine cattle, fifty-four hogs, one horse, and one person were killed. Chickens fared worst; hogs, cattle, and horses not so badly.

With the great destruction of property it is remarkable that only thirteen persons were killed in the Berlin Tornado. However, people caught in the open were usually injured or killed. Deaths were caused by people being blown against objects or being struck with flying debris. Of those killed all were in Berlin except three in the country who had not reached the protection of caves and cellars. Persons situated so that they could see and hear the approach of the storm and who hastened to cellar or cave usually escaped. Nearly all loss of human life was on the northeast slopes without outlook to the southwest. The cellar proved a safe place even when the house was blown away, the southwest corner being the safest position. On the smooth, open country the tornadoes were seen and heard quite a distance and the people probably had from two to four minutes notice of their approach, or time to reach places of safety. People in valleys or on north or northeast slopes taken without warning had less than thirty seconds, for the storm traversed a given point in that time.

We found that the testimony of those who were in the storm was not always reliable, for they received mistaken impressions and honestly reported what did not happen. One man sitting in his kitchen at Berlin felt sure that his house was lifted and whirled around many times. As a matter of fact, the house was largely wrecked but the kitchen was least damaged. On going out after the storm the owner could hardly believe his eyes, for he saw that the kitchen had not left its foundation. The house was near the center of the path. The impression was undoubtedly received from

observing the circular motion of moving articles outside through the window. From the great mass of testimony of eye witnesses and from our own survey and investigation the following very general conclusions may be drawn with respect to these great disasters:

1. The storms developed in the late afternoon during the time of highest temperature, which is the rule for the occurrence of severe thunderstorms and tornadoes in this part of the Mississippi valley. This made their approach noticeable and lessened the loss of life.

2. The tornadoes moved northeastward, sweeping the ground continuously for unusually long distances, forming well marked paths. Their movement was faster than that reported for most tornadoes.

3. In the vortex of at least three storms a velocity of 200 to 400 miles an hour was reached. This was determined by engineering tests of materials that had penetrated other objects. The velocity was so great as to cause soft objects to penetrate hard ones.

4. There was the least loss of life among occupants of buildings on high points with southwest exposure and the greatest loss among those on northeast slopes without outlook to the southwest.

5. Only two persons in the country and small towns were killed in a cellar or cave, in which case the house crashed upon the roof of an old cave.

6. The safety of the cellar or cave seems to be due to the fact that the people therein are below the flying debris which moves with such great velocity and force.

7. The explosive effect on buildings was much less than is usually supposed, the destruction resulting mostly from crashing of buildings against the ground or against trees and other buildings.

8. As a result of these storms, tornado insurance increased in popularity and many people in both city and country are now constructing storm caves.